

## **SECTION 34 21 01**

### **GENERAL REQUIREMENTS FOR THE TRACTION POWER SYSTEM**

#### **PART 1 – GENERAL**

##### **1.01 SECTION INCLUDES**

- A. This Section includes the general requirements for the provision of all electrical equipment, cabling, conduit/cable tray, underground structures and ductbanks, cable trenches, materials, and appurtenances for a complete and operable Traction Power System.

##### **1.02 RELATED SECTIONS**

- A. Refer to the following Sections for requirements:
1. Section 01 11 00 Summary of Work
  2. Section 01 31 19 Project Meetings
  3. Section 01 32 16 Construction Progress Schedules
  4. Section 01 33 00 Submittal Procedures
  5. Section 01 33 23 Shop Drawings, Product Data and Samples
  6. Section 01 35 14 Operating System Interface
  7. Section 01 35 24 Construction Safety
  8. Section 01 35 33 Security Procedures
  9. Section 01 42 19 Reference Standards
  10. Section 01 43 00 Quality Assurance
  11. Section 01 45 00 Quality Control
  12. Section 01 74 14 Cleaning
  13. Section 01 77 00 Closeout Procedures
  14. Section 01 78 39 Contract Record Documents
  15. Section 26 05 53 Identification Requirements
  16. Section 34 21 02 Design and Product Deliverable Requirements for the Traction Power System
  17. Section 34 21 05 Prefabricated AC and DC Equipment Houses and Related Equipment

18. Section 34 21 11 Multi-Function Protection Relay Equipment
19. Section 34 21 17 AC Switchgear (SF 6 Gas Insulated Type)
20. Section 34 21 18 AC Switchgear (Sealed Vacuum Type)
21. Section 34 21 19 Separable Insulated Connectors
22. Section 34 21 20 AC Busways
23. Section 34 21 21 Transformer-Rectifier Units
24. Section 34 21 25 DC Switchgear
25. Section 34 21 27 Liquid Immersed Type Auxiliary Power Transformers
26. Section 34 21 30 Negative Grounding Device
27. Section 34 21 33 Traction Power Control, Monitoring and Display Panel
28. Section 34 21 35 Emergency and Transfer Trip System
29. Section 34 21 40 DC Control Power System
30. Section 34 21 50 Common Materials and Methods for Traction Power
31. Section 34 21 55 DC Manual Disconnect Switch
32. Section 34 21 56 MV Isolation Disconnect Switches
33. Section 34 21 60 Grounding and Bonding for Traction Power Facilities
34. Section 34 21 70 Traction Power Facilities Installation Requirements
35. Section 34 21 75 Traction Power System Level Factory Testing
36. Section 34 21 80 Traction Power System Field Acceptance and Testing Requirements
37. Section 34 22 23 Traction Power Cables
38. Section 34 24 13 Contact Rail System

### **1.03 MEASUREMENT AND PAYMENT**

- A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be included with related items of Work in the Bid Schedule of the Bid Form, or incidental to the Work.

#### **1.04 SUBMITTALS**

- A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.
- B. Safety Equipment as specified in Section 1.07D.8 herein.
- C. FMECA Plan as specified in Section 1.10D herein.
- D. FMECA Report as specified in Section 1.10D herein.
- E. Product Data: Submit product data as specified in Section 1.16D.1 herein.
- F. Product Shop Drawings as specified in Section 1.16D.2 herein.
- G. Site Specific Design Package as specified in Section 1.16D.3 herein.
- H. Calculations as specified in Section 1.16D.4 herein.
- I. Studies as specified in Section 1.16D.5 herein.
- J. Traction Power Cables and LV Equipment as specified in Section 1.16E.1 herein.
- K. Professional Architectural/Engineering Design as specified in Section 1.16F.1 & 2 herein.
- L. Closeout Procedures as specified in Section 1.16G1 & 2 herein.
- M. Asset Management as specified in Section 1.17A & B herein.
- N. Closeout Submittals as specified in Section 1.23 herein.
- O. Maintenance Manual as specified in Section 1.24 herein.
- P. Training Instructor Qualifications and Experience as specified in Section 3.01B herein.
- Q. Training Program Plan, the Instructor's Guides and Attachments, Student Training Materials, Staged Training Program as specified in Section 3.01C herein.
- R. Final Training Deliverables as specified in Section 3.01.I.2 herein.

#### **1.05 REFERENCES**

- A. The Traction Power System shall be designed, fabricated, constructed and tested in accordance with the latest edition of the following codes, standards, and specifications except as provided otherwise herein and elsewhere in the Contract. Where requirements conflict with requirements specified herein the more restrictive requirements shall apply.

- B. American National Standards Institute (ANSI):
  - 1. ANSI C2                      National Electrical Safety Code
  - 2. ANSI Z55.1                Gray Finishes for Industrial Apparatus and Equipment
- C. California Code of Regulations:
  - 1. Title 24, Part 3        California Electrical Code
- D. Institute of Electrical and Electronics Engineers (IEEE):
  - 1. IEEE 1653.2            Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1,500 V DC Nominal Output
  - 2. IEEE 693                Recommended Practice for Seismic Design of Substations
- E. Military Specifications:
  - 1. MIL-STD-1629A        Procedure for Performing a Failure Mode Effect and Criticality Analysis
- F. National Fire Protection Agency (NFPA):
  - 1. NFPA 70                National Electrical Code
  - 2. NFPA 130               Fixed Guideway Transit Systems and Passenger Rail Systems

## **1.06 TRACTION POWER SYSTEM DESCRIPTION**

- A. The Traction Power System comprise of the following subsystems: high voltage substations; 34.5 kV AC sub-transmission system; traction power facilities; 1,000 Volt DC distribution system; and protection, metering, control, and monitoring.
- B. The high voltage substations serve as the receiving point for high voltage power from the local electric utility service provider. These substations are comprised of power transformers and switching equipment to step down the high voltage power to 34.5 kV AC for supply to the traction power substations via the switching stations and the 34.5 kV AC sub-transmission system.
- C. The 34.5 kV sub-transmission system receives its 34.5 kV AC power from the high voltage substations via the switching stations. The system, consisting of two parallel 34.5 kV AC cable circuits which are routed within the transit system right-of-way, transmits the 34.5 kV AC power to the traction power substations.
- D. The traction power facilities include the switching stations, sectionalizing stations, traction power substations, and gap breaker stations. A site may incorporate a combination of these facilities.

- E. The traction power substations convert the 34.5 kV, three-phase, AC power received from the 34.5 kV sub-transmission system to a nominal 1,000 V dc power for distribution to the contact rail system.
- F. Sectionalizing stations provide sectionalizing of the sub-transmission system. One sub-transmission section includes a high voltage substation and a switching station. During an emergency condition caused by the failure of the high voltage substation and/or switching station in a 34.5 kV sub-transmission section, the circuit breakers in the sectionalizing station are closed to transfer the load in the failed section to an adjacent healthy 34.5 kV sub-transmission section.
- G. Switching stations receive the 34.5 kV power from the high voltage substations for supply to the 34.5 kV sub-transmission system.
- H. Gap breaker stations provide switching and allow isolation of contact rail sections on the mainline, pocket tracks, crossovers, and turnouts.
- I. The DC distribution system consists of the DC feeder cables, contact rail system, and the negative return cables that are connected to the running rails providing as return path for negative current back to the substations.
- J. The Traction Power System equipment and facilities are designed for local and remote operation (at the District's Operation Control Center (OCC) (Mainline) and the Yard Control Towers (YCT)).
- K. Traction power equipment is designed and equipped with protection devices to protect equipment and personnel against electrical faults and abnormal system conditions.
- L. Metering devices are provided in key circuit locations for local and remote measurement and recording of electrical operating parameters.

#### **1.07 QUALITY ASSURANCE, QUALITY CONTROL AND SUPPLIER QUALIFICATIONS**

- A. Refer to Section 01 43 00, Quality Assurance and Section 01 45 00, Quality Control for quality control, quality assurance and qualification requirements.
- B. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100. Electrical components, devices, and accessories shall comply with NECA 1, Standard for Good Workmanship in Electrical Construction.
- C. The Contract indicates preliminary dimensions for equipment, including clearances between equipment and for adjacent surfaces and other items. Deviations to indicated or noted dimensions shall be submitted to the District for review and approval.
- D. The equipment vendor's engineer, in charge of the design of the traction power facilities, must have project-proven experience in the design and manufacture of

traction power facilities for mass transit, and shall be subject to approval by the District.

- E. The engineer from the rectifier transformer manufacturer organization, in charge of the design of the rectifier transformers, must have a minimum of five years of project-proven experience in the design of three-winding rectifier transformers.
- F. The manufacturer of the Traction Power System's equipment and cables shall have a minimum of five years of successful and proven transit, industrial, or utility experience of providing equipment and cables like those furnished under the Contract.
- G. The manufacturer of the rectifier transformer must have a minimum of five years manufacturing experience with three-winding, oil-filled and/or dry type rectifier transformers utilizing IEEE 1653.2 Circuit No. 31 configurations of the same voltage class as specified in Section 34 21 21, Transformer-Rectifier Units.
- H. Equipment, devices, components, cabling, materials, and appurtenances shall be proven standard products, or equivalent to the standard products of manufacturers engaged in the production of such entities for at least the past five years.
- I. Equipment, devices, components, cabling, materials, and appurtenances shall be designed to operate within the specified environmental conditions specified below.
- J. All materials shall be new, unused in any other application, and shall possess properties and characteristics in accordance with the applicable industry standards. All equipment, including parts and devices, shall be new, the manufacturer's latest standard designs that conform to the Contract, and free from defects in material and workmanship.
- K. Furnish at the time of Bid certifications of compliance concerning the experience records of the manufacturers, engineers, and electrical Subcontractors, substantiated with documented information and references; and product years-in-service data, as required.
- L. Components of major equipment, such as relays, control switches and protective devices, do not have to meet the five-year experience requirement.
- M. All prescribed equipment, materials, cables and appurtenances shall not only be designed and constructed to operate within the intended application and operating environment, but also have a proven track record of successful operation.

#### **1.08 GENERAL FUNCTIONAL, OPERATIONAL, PERFORMANCE REQUIREMENTS**

##### **A. Safety Design**

- 1. The Traction Power System design and operational procedures shall incorporate the following as a minimum:
  - a. Avoiding, eliminating, or reducing hazards identified by engineering analysis, design choices, material selection, or substitution.

- b. Controlling and minimizing hazards (to personnel, the public, and to equipment and materials), which cannot be avoided or eliminated.
- c. Incorporating fail-safe principles where failures would disable the system or cause human injury, damage to equipment, or inadvertent operation of critical equipment.
- d. Locating equipment components so that access to them by the required personnel during operation, maintenance, repair, or adjustment shall not require exposure to hazards such as entrapment, chemical burns, electrical shock, cutting edges, sharp points, or toxic atmospheres.
- e. In addition to equipment enclosure doors protective barriers/insulated covers limiting contact to energized terminals and/or buses shall be incorporated into the design of equipment.
- f. Providing suitable warning and caution notes in operations, assembly, maintenance, and repair instructions; and distinctive markings on hazardous components, equipment, or facilities for personnel protection.
- g. All components containing or generating obnoxious, flammable, and harmful gases shall be vented to the outside.
- h. Cables and wires of different systems and high and low voltage conductors shall be physically segregated/separated from each other in accordance with the requirements specified in the NEC and CEC.

B. Security

- 1. All equipment enclosures and equipment houses shall have a District approved locking device.
- 2. Refer to the Contract for locking/security hardware requirements which are subject to the approval of the District.

C. Uniformity and Standardization

- 1. Equipment enclosures, assemblies, sub-assemblies, and components that do not differ in operational, functional or performance characteristics shall be designed so that all components are positioned in the same location and internal wiring is routed in between components in a like manner.
  - a. Equipment providing like functions shall be of the same design and manufacturer.
  - b. Equipment or devices of the same rating and function shall be identical and interchangeable.
- 2. Where identical installations exist, the following requirements shall be adhered to:
  - a. Unless Jobsite conditions prevent it, equipment enclosures shall be mounted and installed in a like manner.

- b. Penetrations for conduit, grounding, and access panels shall be located in the same place.
- c. The location of equipment relative to adjacent equipment shall not differ.
- d. The routing of conduit, cable tray, wireway, and cables between equipment enclosures shall not differ.
- e. Termination hardware shall be located in like manner.
- f. Cables and wire terminations shall be located in like manner.

D. Equipment Construction

1. General Requirements

- a. The surfaces of the equipment shall be smooth, free of gaps, burrs, sharp edges, wrinkles, waves, or blemishes and shall have uniformly rounded corners with constant radii.
- b. Full height doors for equipment such as switchgear and cabinets shall have a three-point locking latches where applicable and 1/4-turn "tee" handles for exterior equipment. For doors four feet or less in height, two-point locking latches are permitted. Each door shall be provided with a cylinder lock or provision for padlock.
- c. Openings and mounting holes for front-mounted indicating and control devices shall be cut out or punched without marring or distorting the exposed finished surfaces.
- d. Surfaces to be welded shall be clean and free of dirt, rust, and other foreign materials in accordance with industry standards. All welding shall be performed by electric arc method or resistance spot welding, and the process shall conform to the standards of the American Welding Society.
- e. Equipment enclosures shall be provided with grounding lugs.
- f. All items, which require inspection, operation, or maintenance, shall not be higher than 72 inches off the finished floor and shall be accessible from the front or the rear.

2. Arrangement

- a. Equipment arrangements indicated are intended to fit the available spaces while providing adequate personnel safety and accessibility for maintenance. Prepare equipment arrangement drawings using actual dimensions of individual equipment, and maintaining the same minimum equipment clearances and aisle widths. Equipment clearances and aisle widths shall be increased if required for normal operation and maintenance of the furnished equipment.
- b. All equipment and components shall be readily accessible for inspection, maintenance, adjustment, and reading of data. Protective relays and other devices from which data are to be read shall be mounted semi-flush on the front panels.



- c. All control devices mounted on front panels and those requiring replacement or adjustment inside panels or compartments, shall be limited to a mounting height not exceeding six feet.
  - d. Devices not on the front panels shall be mounted on the surface of internal panels, accessible by opening the hinged front panel.
  - e. Each device shall be located and wired so that it can be serviced without removing the device or other devices.
  - f. Devices on the front panel of equipment shall be mounted plumb and square with the lines of the panel, and the mounting shall be as recommended by the device manufacturer.
  - g. All potentially energized components shall have 12 inches minimum spacing between energized components, or shall be insulated to preclude accidental contact by maintenance personnel.
3. Equipment and Cable Entrance Enclosure/Box Rating
- a. All indoor enclosures shall be rated as NEMA 12/12K.
  - b. All outdoor enclosures located above ground shall be rated as NEMA 3R.
  - c. All enclosures located underground shall be rated as NEMA 3R or 4X and comply to the requirements specified in NFPA 130.
  - d. Alternative equipment enclosure NEMA classifications, to those noted above, that are suitable for the environment to which the equipment is exposed shall be considered but are subject to the District's approval.
4. Seismic Design Requirements (for Equipment, Utilities and Related Supports and Anchorages)
- a. Equipment design, including device mounting, supports, materials, and installation methods shall conform to the requirements outlined in IEEE 693.
  - b. Equipment, conduit, busway, cable tray, and associated mounting hardware and anchors shall be designed to operate in a seismically active area, and shall comply with the special seismic design requirements as specified herein:
    - 1) Equipment, Utilities and Related Supports and Anchorages on New Facilities

- a) Seismic design shall comply with the provisions of CBC Section 1613. and ASCE/SEI 7-, Chapter 13 except as modified herein.
  - b) Traction power system elements, including related traction power, fire protection, ventilation, emergency power and lighting, and communication equipment and related supports and anchorages are considered essential equipment and shall be designed using an Importance Factor,  $I_p = 1.5$ .
- 2) Equipment, Utilities and Related Supports and Anchorages on Existing Facilities
  - a) Seismic design shall comply with the CBC Section 1613. and ASCE/SEI 7-, Chapter 13 except as modified herein.
  - b) Seismic design shall consider the relative motions between the points of attachment to the structures.
  - c) Importance Factor  $I_p$  shall be in accordance with the Specifications Section Article 1.07D.4.b.1.b above.
- 5. Equipment Painting
  - a. All ferrous metal surfaces of enclosures and equipment shall be factory painted by UL-recognized painting system to prevent rust and painted inside and out per manufacturer's standard unless otherwise specified. Interior brackets, supports, or steel barriers may be unpainted provided they are fabricated from galvanized steel. Standard, off-the-shelf equipment procured from other manufacturers is acceptable with its original paint.
  - b. Follow standard published factory painting procedures for electrical equipment.
  - c. Unless advised to the contrary the finish equipment enclosure color shall be per ANSI Z55.1; Type 61 light gray, semi-gloss.
  - d. A gallon of touch-up paint shall be provided at each traction power facility for each paint type used on each equipment enclosure.
  - e. Refer to Section 34 21 05, Prefabricated AC and DC Equipment Houses and Related Equipment, for additional requirements relating to the AC and DC equipment houses.
  - f. Refer to Section 34 21 20, AC Busways, for additional requirements relating to the AC busways and supporting structures
- 6. Prohibited Materials
  - a. No polychlorinated biphenyl (PCB), asbestos, or other materials with known toxicity posing health hazard upon handling and human contact shall be used in any parts or products of the Traction Power System.
- 7. Static Signs
  - a. Refer to Section 26 05 53, Identification Requirements for identification requirements and the Contract drawings for additional requirements.

- b. Furnish and install static sign to the electric utility metering cubicle that specifies the billing address
  - c. Furnish and install electrical safety signs on all doors and access panels of electrical equipment, and on the outside doors of the AC and DC equipment houses, equipment enclosures, perimeter security barrier and gates, in accordance with applicable industry standards, safety regulations and as prescribed within the BART Facilities Standards.
  - d. Furnish and install video surveillance, trespassing, PPE notification, hazardous material and video surveillance signs on all site perimeter entrance gates, and within 50 feet of each perimeter wall/fence corner (where it exceeds 100 feet).
  - e. Furnish and install traction power facility designation on each side of the perimeter wall/fence.
  - f. Furnish and install parking stall signage.
  - g. Furnish and install blue light station signage per NFPA 130.
  - h. The wording, size, and other details of the signs shall be coordinated with the Engineer.
  - i. Mount static signs to exterior side of the perimeter wall/fence and equipment enclosures.
  - j. Attach signs with stainless steel fence flips and/or pamper proof anchors.
8. Safety Equipment
- a. First Aid Kit: Provide a complete first aid kit in accordance with the requirements of Cal OSHA and the local ordinances at each traction power facility.
  - b. Emergency Eyewash: Provide hardlined eye wash system at each traction power facility.
  - c. Provide a hot-stick at each traction power facility.
  - d. Personal Protective Equipment: A complete set of Personal Protective Equipment (PPE), as prescribed by the manufacturer and Cal OSHA, shall be provided at each traction power facility. The PPE shall include at least the following:
    - 1) Arc Flash Protection Suit.
    - 2) Eye Protection.
    - 3) Acid/electrolyte-resistant gloves and apron.
  - e. Coordinate size of PPE with the District prior purchase and delivery to site.
  - f. Submit design and product and data for specified safety equipment.
9. Single Line Diagram

- a. A condensed single line diagram, sized 11 inches by 17 inches, shall be provided in a polyvinyl frame for at each traction power facility in the AC and DC equipment houses.

E. Equipment and Wiring

1. Equipment Arrangement - Preliminary arrangements and locations of equipment, devices, and components are specified in the Contract. Submit detailed and dimensioned arrangement and location drawings for the Districts approval prior to fabrication work. The arrangement shall result in minimum space requirement and optimum accessibility for maintenance; and follow NEMA, NESC, NEC, CEC, PG&E requirements, and industry standards. Equipment, devices, and components shall be arranged to be conveniently accessible and easily visible. Grouping shall be neat, modular, and logical with related functions in proximity. Devices shall be plumb and square with the lines of the panel and mounted as recommended by the manufacturer. Care shall be taken to avoid wiring congestion. All auxiliary devices shall match the general appearance as far as possible with the frames of a compatible dull black. All devices on the panel face shall be semi-flush mounted. Devices and raceways of the same general type shall be manufactured by the same company and shall be similarly arranged and mounted.
2. Accessibility - All equipment and components shall be readily accessible for inspection, maintenance, adjustment, and reading of data. All devices, including protective relays, from which data are to be read, shall be mounted on the front panels. Devices mounted on the front panels and elsewhere shall be limited to a height of 72 inches from the floor. The minimum height for panel-mounted devices shall be 18 inches from the floor. All other devices shall be readily accessible on the surface of the equipment or by opening a hinged door or panel without removing another device or equipment other than by drawing out the circuit breaker.
3. Equipment Integrity - Equipment as assembled for operation shall have no openings, which would allow the accidental entry of hand tools and the like. Circuit breaker arcing in normal and fault clearing operations shall be controlled to protect the operating personnel and to not jeopardize the structure and/or finish.
4. Equipment Reparability - Equipment furnished under the Contract shall be field repairable to the maximum extent possible, to facilitate on-site maintenance and repair by the District, using its own facilities and personnel. Return of equipment to the manufacturer's facilities, for repair or replacement, shall be required only where necessary to comply with Warranty provisions.
5. Wiring Arrangement - All power and control wiring and labeling shall be the same for all traction power facilities. Termination labels and wire markings shall be used for all similar equipment at all traction power facilities.
6. Wiring and cabling of different applications and/or voltages shall be segregated in accordance with the NEC/CEC.

F. Aesthetics

1. Traction power facility sites, equipment houses and equipment enclosures shall be designed to minimize the adverse visual impact on the areas in which they are located and to comply with the appropriate federal, state, and local architectural and environmental guidelines.

G. Accessibility, Maintainability and Safety Requirements

1. Enclosures shall not be placed in direct contact with equipment foundation and/or perimeter security wall surfaces. Install shims and caulk and grout between buildings or enclosures and concrete.
2. All enclosures shall be identified in accordance with the District's naming convention, as specified in the approved design deliverables.
3. Permanent ladder/steps shall be provided in the design of all underground structures and/or cable trenches, where the depth exceeds three feet.
4. Equipment and/or equipment house final placement shall not obstruct vehicle access into and around the traction power facility sites through the gates.
5. Placement of the 34.5 kV junction cubicles, 34.5 kV isolation disconnect switches, and/or 1,000V DC disconnect switches within traction power facility sites shall not prohibit vehicle circulation around equipment and/or switchgear houses.
6. Provide vehicle barriers within traction power facility sites where vehicle circulation is within ten feet of equipment and/or equipment houses.
7. Provide vehicle barriers around third party utility equipment in accordance with the requirements of the respective third party utility service providers.
8. Equipment, structural supports, foundations and containment wall placement shall not impede egress from the AC and DC equipment houses, rectifier transformers and auxiliary transformer to the perimeter gates. Maintain a minimum three foot horizontal and seven foot vertical clearance anywhere around equipment, houses and structures.
9. Provide level working platforms, with sufficient horizontal clearance in accordance with NEC, CEC and NESC, in front of equipment that will need to be accessed. The height of the working platforms above finished grade shall ensure equipment/components that need to be accessed does not exceed 6 feet above finished working platform surface.
10. Placement of auxiliary equipment, exterior site light fixtures, poles and/or vehicle barriers shall:
  - a. Consider vehicle movement in and around the equipment and equipment houses.
  - b. Not obstruct equipment removal and/or replacement.

11. The design of the stairway/platform associated with the doorway (at both AC and DC equipment houses) designated for circuit breaker removal/replacement shall include removable handrails.
12. Non traction power cables and/or equipment shall not be placed within the AC and DC cable trenches.
13. The MV cables associated with a circuit shall be physically separated from other circuits and shall not occupy or be routed within the same cable tray and/or conduit within the AC and DC cable trenches.
14. The design of underground structures and cable trenches shall prevent covers from falling onto cables.
15. The orientation and final placement of the AC and DC equipment houses, rectifier transformers and auxiliary transformers, relative to each other and the perimeter security barrier shall not impede equipment removal and/or replacement.
16. Sump pump structures shall be constructed adjacent to the AC and DC cable trenches and their design shall prevent direct access between sump pump enclosure and cable trenches. Electrical distribution and control equipment associated with sump pumps shall be located at grade.
17. The placement of outlets from sump pump structures and containment areas, and site grading, shall ensure water ingress into underground structures shall not occur.
18. Where trackside light fixtures are located adjacent to or on the perimeter security barrier, ensure the fixtures are placed within the site limits of the traction power facilities or can be accessed from within the site limits of the traction power facilities without exposing personnel to the trackway right-of-way limits.

Existing traction power facility site layouts may prohibit compliance to some of the above noted requirements. Reference Contract drawings for specific site requirements.

#### **1.09 POWER FOR AUXILIARY DEVICES**

- A. Power for all devices and their subsystems used for control, indicating, or supervision function shall be derived from the 125 V DC station battery system. Separate low-voltage batteries are allowed only as back-up power supply. Back-up batteries, if used, shall automatically recharge after use, upon restoration of normal power supply.

#### **1.10 NOISE LEVELS**

- A. The design of the traction power facilities and/or equipment shall meet the specified maximum allowable noise levels. Equipment design, enclosures with acoustic

mitigation capability, and other measures, as appropriate, shall be employed to achieve compliance with the audible noise level criteria.

The noise level outside the traction power facility, measured at 15 feet from any equipment during operation shall not exceed 55 dB. Where site conditions prohibit the noted measurement apply the following noise levels to the available maximum distance at the traction power facilities.

DISTANCE (FEET)	NOISE LEVEL (dB)
1	80
3	69
5	65
7	62
9	60
11	58
13	57
15	55

- B. The noise level inside the AC and/or DC equipment houses, measured at five feet from any equipment during operation, shall not exceed 70 dB.
- C. Refer to Section 34 21 75, Traction Power System Factory Functional Testing and Section 34 21 80, Traction Power System Field Acceptance Testing for additional requirements.

#### **1.11 FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS (FMECA)**

- A. As part of the design development process perform a detailed qualitative and quantitative FMECA, in accordance with MIL-STD-1629A, that comprehensively provides an appraisal of all possible ways in which the Traction Power System (and its associated systems, equipment, assemblies, sub-assemblies, components and software) and associated interfaces to other systems may fail under worse case conditions within the intended environmental and operational conditions and, the potential consequence of these failures. The FMECA, as specified in MIL-STD-1629A, shall include the following:
  - 1. Failure Mode and Effects Analysis.
  - 2. Criticality Analysis.
  - 3. Maintainability Analysis/Information.
- B. The FMECA shall include, but not limited to, the following systems and/or assemblies, as part of the analysis:
  - 1. AC and DC Equipment Houses.

2. Separable Insulated Connectors.
  3. MV Isolation Disconnect Switches.
  4. AC Switchgear and AC Circuit Breakers.
  5. AC Busway.
  6. Rectifier Transformers.
  7. Auxiliary Power Transformers.
  8. Rectifiers.
  9. DC Switchgear and DC Circuit Breakers.
  10. DC Disconnect Switches.
  11. SCADA System (inclusive of the Mimic Panel and HMI).
  12. Emergency and Transfer Trip System.
  13. 125 V DC Battery System.
  14. IPRs and MPRs.
- C. The scope of the FMECA shall only include those elements of the Traction Power System that are part of the Work, as defined in the Contract.
- D. Submit the following documentation to the District for review and approval:
1. FMECA Plan.
  2. FMECA Report.
- E. A previous FMECA report produced in the ten years preceding Contract award can be submitted to the District in lieu of conducting FMECA if the Contractor formally certifies and demonstrates the systems, equipment, assemblies, sub-assemblies, components and software being provided under the Contract meet the following conditions:
1. The design of the systems, equipment, assemblies, sub-assemblies, components and/or software is equivalent to the specified contract requirements without exceptions.
  2. The design of the systems, equipment, assemblies, sub-assemblies, components and/or software do not need to be modified/changed to comply to the requirements of the Contract and the submitted FMECA validates this basis.
  3. Changes in systems, equipment, assemblies, sub-assemblies and/or components designations do not reflect material changes in their design.



4. The design of the systems, equipment, assemblies, sub-assemblies, components and/or software has not changed in the ten years prior to awarding the Contract.
  5. Component suppliers have not changed the fabrication process and/or material sourcing in the ten years prior to awarding the Contract.
- F. The design deliverables of the Traction Power System shall include a traceability matrix that demonstrates how the results and recommendations of the FMECA report were incorporated into the final design.

#### **1.12 FAILURE OF ELECTRONIC DEVICES**

- A. Electronic devices, including microprocessor-based devices, shall be equipped with self-monitoring and self-test features. As a minimum, these devices shall be provided with local indication of device failure, visible on the front panel of the cubicle on which the device is located.
- B. Where device failure affects the operation of the main power circuit that it serves, or causes an unsafe condition, device failure shall be indicated on the local annunciator, and an alarm sent to the Operations Control Center (OCC).
- C. Failure of a device or loss of its power supply shall not cause false indication, prevent annunciation/indication at the OCC, nor prevent a circuit breaker from being tripped by manual, local, or remote control.

#### **1.13 DESIGN LIFE**

- A. Equipment, cables and other materials shall be designed for the following service life, under the applicable ambient environmental conditions specified below
  1. AC and DC switchgear, rectifier transformers, rectifiers, auxiliary power transformers, AC and DC circuit breakers, negative grounding devices, manual disconnect switches, 34.5 kV isolation disconnect switches, and cables: - 30 years.
  2. Batteries: - 20 years.
  3. Battery charger: - 20 years.
  4. SCADA System (inclusive of the Mimic Panel and HMI): - 20 years.
  5. Emergency and transfer trip system: - 20 years
  6. IPRs and MPRs: - 20 years.
  7. Materials shall be new and of the highest quality available for the Work as specified.

**1.14 ELECTROMAGNETIC AND ELECTROSTATIC SUSCEPTIBILITY**

- A. The traction power system's equipment shall not be adversely affected by radiated or conducted electromagnetic or electrostatic interference from trains or fixed sites and other electric/electronic equipment on or within one mile of the District's right-of-way including but not limited to the following; trains operating within the guideway, fixed site equipment, cellular telephones, mobile radios, incidental (spurious) radiation equipment, ignition noise, lighting fixture, electrical power system transients, vehicular systems, and electrostatic discharge.
- B. Investigate all electromagnetic and electrostatic susceptibility factors that may affect equipment operations both before and after installation of the equipment. Electromagnetic and electrostatic susceptibility deficiencies uncovered during installation testing, on-line demonstration, or final tests may be cause for additional design adjustments and additional testing at no additional cost to the District.

**1.15 PROJECT ENVIRONMENTAL CONDITIONS**

- A. The Traction Power System shall operate continuously in the follow operating environment:
  - 1. Elevation: The lowest and highest part of the alignment where traction power facilities are located adjacent too is between 0 feet and 1000 feet respectively above sea level.
  - 2. Temperature: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the annual atmospheric ambient temperature range in degrees Fahrenheit.
  - 3. Relative Humidity: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the annual relative humidity range as a percentage.
  - 4. Typical Wind Conditions: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the annual mean wind speed and maximum wind speed.
  - 5. Rainfall: The following rainfall levels shall be assumed:
    - a. Normal Annual: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the range in inches.
    - b. Maximum in 24-hour period: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the maximum in inches.
    - c. Maximum in one-hour period: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the maximum in inches.

- d. 90 percent of Average Annual Precipitation occurs between November and April.
- 6. Floods: The Traction Power System shall be designed for the peak run-off from a 100-year storm.
- 7. Snowfall, Ice Pellets, and Icing: The District's alignment experiences minimal levels of snowfall, ice pellets, and icing; and therefore, their impact on the design of the Traction Power System shall be ignored.
- 8. Number of Thunderstorm Days per Year: Refer to the BART Facilities Standards, Introduction, Operations Common Data, Climate and Seismology for the number of days per year to be assumed.
- 9. Fog: Heavy fog is common to some areas of the District's alignment and therefore shall be assumed, for design purposes, for the complete alignment.
- 10. Soil Resistivity: Refer to the supporting documentation provided as part of the Contract.
- 11. Seismic: The District's alignment and associated support facilities are in a seismically active area. Refer to the BART Facilities Standards Design Criteria, Structural, Seismic Design for specific requirements.
- 12. Atmospheric Pollution/Contamination: Refer to the supporting documentation provided as part of the Contract.
- 13. Hazards and Hazardous Materials: Refer to the supporting documentation provided as part of the Contract
- B. Equipment and devices inside traction power facilities shall be designed and rated for operation at 50 degrees Celsius ambient temperature.

#### **1.16 DESIGN CRITERIA – LOW VOLTAGE CIRCUITS**

- A. The following criteria for voltage drop shall apply to the low voltage circuits and the Contractor shall demonstrate compliance to the requirements through the calculations noted below:
  - 1. Sensitive Electronic Equipment (e.g. C02 HMI, IPRs, MPRs, fiber optic media converters, network switches, PLCs)
    - a. 1.5 percent or less on branch circuit conductors.
    - b. 2.5 percent or less on combined feeder and branch circuit conductors.
  - 2. LV Power and Lighting Circuits, and 125 V DC Control Power Circuit
    - a. three percent or less on feeder circuit conductors at the farthest field device in the circuit.

- b. five percent or less on combined feeder and branch circuit conductors at the farthest field device in the circuit.

#### **1.17 DESIGN DELIVERABLES**

- A. Refer to General Conditions (GC 4.12) and associated Supplemental Conditions for the terms and conditions relating to work product ownership.
- B. Refer to the following Sections for additional requirements:
  - 1. Section 01 33 00 Submittal Procedures.
  - 2. Section 01 33 23 Shop Drawings, Product Data and Samples.
- C. General
  - 1. All deliverables shall be signed and sealed by a Professional Engineer licensed in the State of California.
  - 2. Refer to Section 01 43 00, Quality Assurance, Section 01 45 00, Quality Control, and Section 34 21 01, General Requirements for the Traction Power System for the quality control, quality assurance and qualification requirements.
  - 3. The Traction Power System shall be compliant with the Federal, State, and local ordinances, industrial publications and the BART Facilities Standards requirements as specified in the Contract.
  - 4. Coordinate the design with the third party utility service providers' existing infrastructure and ensure the design complies with their respective design standards outside the District's Right-of-Way (ROW). Within the District's ROW comply to the requirements specified in the Contract.
  - 5. Coordinate the design of the Traction Power System with the respective designs of the Architectural, Civil, Structural, Utility, Mechanical, Electrical and Systems disciplines.
  - 6. All design deliverables shall be produced in accordance with the CADD requirements as set forth in the BART Facilities Standards.
  - 7. Calculations:
    - a. Calculations and studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in the Contract. An organization experienced in the application of computer software used for calculations and studies, having performed successful calculations and studies of similar magnitude on Traction Power System using similar devices.

- b. Calculations and studies shall utilize equipment, component, wire, fiber strands and cable designations that correlate with product and design deliverables specified herein and elsewhere in the Contract.
8. Where products specified in the Contract, are required to conform to the standards of organizations such as ANSI, ASTM, NEMA, and UL, the Contractor shall submit evidence of such conformance to the District for review and record purposes.
9. All submittals specified in the Contract shall be submitted for review and approval with ample time to prevent delays in the Work. Additionally, the sequencing of submittals needs to consider their inter-relationship and shall be reflected in the Contractor's Project Schedule.
10. The Traction Power System design submittals shall be organized in separate packages, containing at a minimum the following:
  - a. Main Traction Power Equipment. Included in the package shall be the AC and DC equipment houses and all equipment inside them, as well as all other surface mounted equipment on the traction power facility sites, such as rectifier transformers and auxiliary power transformers.
  - b. Emergency and Transfer Trip System (ETTS). This package shall cover all ETTS related devices and subsystems, including fiber optic and control cabling, equipment in train control rooms, wayside blue light stations, and platform trip stations.
  - c. Traction Power Feeders and Raceways. Included in the package shall be 35 kV cables, 34.5 kV system raceways, elbows and bolted type connectors, 34.5 kV junction cubicles, 34.5 kV isolation disconnect switches, 34.5 kV splices and splice boxes, 34.5 kV spark gap assemblies, 2.4 kV DC cables for positive and negative return feeders, DC raceways up to the track side and termination details, associated accessories, and cable pulling calculations for the AC and dc feeders.
  - d. Traction Power Siteworks. Included in this package shall be site plans for each traction power facility, foundation design including trenches and cable trays near and under AC and dc equipment houses, all underground raceways within the TP site boundaries, ground grid design and grounding details, and civil aspects of the site design, such as paving, fencing and access provisions.
  - e. Interfaces with the existing BART System. Included in this package shall be all designs related to the interface of the Traction Power System with the existing BART System, including modifications to existing BART facilities and equipment.
  - f. Contact Rail System Components. This package shall include the design of individual components of the contact rail system, including hardware for interfacing with the positive traction power feeders and jumper cables.
  - g. Contact Rail System Layouts. This package shall include scaled drawings showing the detailed and final design of the contact rail system. The

drawings shall include exact locations of end-ramp assemblies, gap dimensions, anchor assemblies, expansion joints, contact rail jumpers and dc feeder connection plates.

h. Contact Rail System Installation Details.

11. Hard and soft copies of the deliverables shall be submitted to the District.

12. In the case of studies:

- a. A separate CD of the original source format of input data used as direct input to the selected software to perform the calculations, generate the reports, generate the tabulations, plot the curves and graphs, and the list the device settings for the as-built facilities shall be submitted to the District.
- b. The name and manufacturer of the software utilized to perform the calculations, prepare the reports, make tabulations, plot the curves, graphs, and drawings with the specific version used. This specific reported software shall be able to take the original source format information submitted above and generate associated tabulations, plot the curves and graphs, perform the calculations, and list the device settings for the as-built facilities submitted as paper and electronic copies. Submit all setup information for using the software used to generate the studies and reports submitted.

13. The design deliverables shall account for the spares requirements as specified elsewhere in the Contract.

14. Refer to the individual equipment Sections listed in Art. 1.02 above for additional requirements.

#### D. Traction Power Equipment Vendor Deliverables

##### 1. Product Data

- a. Product data shall be provided for all equipment, cables, materials and appurtenances provided under the Contract.
- b. Product data shall include, but not limited to, the following
  - 1) Modify manufacturers' standard schematic drawings to delete information that is not applicable to the Contract. Supplement standard information with additional information applicable to the Contract.
  - 2) Modify manufacturers' standard catalog cuts, brochures, diagrams, schedules, performance charts, illustrations, calculations, and other descriptive data to delete information that is not applicable to the Contract. Indicate dimensions, clearances, performance characteristics, capacities, wiring and piping diagrams, and controls.
  - 3) Modify manufacturer's printed installation, application, and instructions to delete information that is not applicable to the Contract.

2. Product Shop Drawings

- a. Product shop drawings shall be provided for all equipment provided under the Contract.
- b. Product shop drawings shall include, but not limited to, the following:
  - 1) Assembly drawings.
  - 2) Dimensional information (including clearances to adjacent equipment/etc.)
  - 3) Internal physical arrangement and assembly of detail parts in each item of equipment.
  - 4) Mechanical and electrical details.
  - 5) Wiring and connection diagrams.
  - 6) Wiring numbers between devices and equipment terminal blocks.
  - 7) Elementary schematic drawing number where the device appears.
  - 8) Brief description of the device functions and special features.
  - 9) Manufacturer's name.
  - 10) Manufacturer's part, model, type or style number.
  - 11) Device rating.
  - 12) Number, type and rating of contacts, if applicable.
  - 13) Internal schematic diagrams.
  - 14) Outline of device and external terminal locations and numbers.

3. Site Specific Design Package

- a. Site specific design packages shall be provided for each new traction power facility, AC switchgear house, DC switchgear house, rectifier transformers and/or ancillary transformer provided under the Contract.
- b. Site specific design packages shall include, but not limited to, the following:
  - 1) Table of Contents.
  - 2) Symbols, abbreviations, device tables, equipment designations, and notes used on all design drawings.
  - 3) Arrangement drawings showing locations of control and protective devices on panels.
  - 4) Floor plans of complete equipment assemblies showing dimensions necessary for installing equipment, equipment base details, available space for entrance of power, control and communications cables, and dimensions and weights of major sections.
  - 5) Section views of each non-identical unit showing bus and equipment locations and locations of outgoing power and control terminals. Drawings shall be in sufficient detail to illustrate accessibility for maintenance and for adjustments while energized.

- 6) Single-line meter and relay diagrams.
- 7) Schematic diagrams of equipment assemblies showing devices, wire numbers, internal and external wiring. Diagrams that do not portray the physical wiring of the panel will not be approved.
- 8) Schematic diagrams and technical data for the automatic reclosing and load measuring system.
- 9) Emergency and Transfer Trip System (ETTS) drawings. These drawings shall show all components, functionality and operational logic of the ETTS. The emergency trip system drawings shall also indicate the locations of all platform trip stations and wayside emergency trip (blue light) stations, and the associated wiring diagrams.
- 10) Functional, logical and schematic diagrams of the ETTS equipment, including individual devices and interfaces with the dc switchgear, and with wayside emergency trip and platform trip stations.
- 11) Multifunction relays and PLC interface drawings. These drawings should show the multifunction protective relays on the dc and AC side of the traction power facilities and their interfaces, and the interfaces of the traction power facility's programmable logic controller (PLC).
- 12) Physical layout, functionality and control schematic drawings for the control panel (C02).
- 13) Layout, equipment arrangement, annunciation, metering and control functions of the traction power facility's C02 panel, including C02 PLC interfaces, settings, display screens, logical diagrams and functionality.
- 14) Traction power facility C02 PLC and ETTS SPC data and details, including logical and functional diagrams, as required for all aspects of operation and maintenance. Similar for all communication interface devices in the traction power facility, such as Ethernet switches, media converters, and Ethernet input/output modules.
- 15) Communication interfaces and schematic diagrams for the inter-device communications within the traction power facility.
- 16) Logic diagrams.
- 17) Detailed SCADA points lists drawings.
- 18) Programmable logic controller (PLC) annunciation/alarm screens. Layouts, alarm messages and functions.
- 19) DC circuit breaker control schematic drawings, including all multifunction protective relay (MPR) interfaces, SCADA, local control interfaces and interlocking, as appropriate.
- 20) AC circuit breaker control schematic drawings, including integrated protective relay (IPR) interfaces, SCADA, local control interfaces, and auto-transfer logic, as appropriate. For 34.5 kV sectionalizing breakers, also interlocking logic with adjacent switching stations and measures for prevention of accidental paralleling of adjacent 34.5 kV circuits supplied by different high-voltage substations.
- 21) NGD control schematics.



- 22) Low voltage power, lighting, heating and ventilation, and miscellaneous system drawings within the AC and/or DC equipment houses.
- 23) Grounding system drawings within the AC and/or DC equipment houses, rectifier transformers and AC busways.
- 24) Structural drawings for AC and DC equipment houses, and equipment mounted within the houses.
- 25) Structural drawings inclusive of anchorage for the AC busway supports.
- 26) Plans and side views, equipment arrangement, and installation details of the 34.5 kV junction cubicles and/or 34.5 kV isolation disconnect switches interfacing the along-track 34.5 kV distribution feeders with the traction power facilities.
- 27) Nameplates and signs showing legends, letter sizes, material, and color information.
- 28) Equipment nameplate data, catalogue cuts, data sheets and recommended spare parts lists.
- 29) Connection diagrams showing the internal wiring and terminal block arrangement and identifying each outgoing power and control terminal.
- 30) Complete equipment and intrabuilding raceway layout drawings, including the raceway and circuit schedules.
- 31) Detailed instructions for connecting the various shipping sections together complete with connection diagrams. The connection diagrams shall identify the terminals to be connected between the shipping sections, and the type and size of cables required for the connections.
- 32) Default settings, parameters and menus of all multi-function relays
- 33) Settings, access details and operational details of the facility's alarm and annunciation panel/screen.
- 34) Metering and data retrieval devices and related details.
- 35) Switchgear breaker test value of the transient recovery crest voltage and the time to reach transient recovery crest voltage.
- 36) Transformer data including rated kVA, frequency, primary and secondary voltages, percent taps, polarity, impedance and certification of transformer performance efficiency at indicated loads, percentage regulation at 100 percent and 80 percent power factor, no-load and full-load losses in watts, percent impedance at 75 degrees Celsius, hot-spot and average temperature rise above 40 degrees Celsius ambient temperature, sound level in decibels, and standard published data.
- 37) Fire alarm system layout plan, schematics and notes.
- 38) Any supplementary data required by the District to assure that the Contract has been accurately interpreted.
- c. Where modifications are made to existing traction power facilities/equipment the Contractor shall electronically reproduce the District furnished as-built/record drawings and revise them to reflect the

modifications. Provide supplemental site specific design drawings to the reproduced and modified drawings as required.

- d. In addition to the design development in-progress and final submittals, per Section 01 33 00, Submittal Procedures provide as-shipped (to site) site specific designs that incorporate all changes made in the factory prior to shipment to the Jobsite.

#### 4. Calculations

- a. Calculations shall be provided for each new traction power facility, AC equipment house, DC equipment house and/or rectifier transformer provided under the Contract.
- b. Calculations shall include, but not limited to, the following:
  - 1) Design calculations for the transformer-rectifier unit, including transformation ratio, commutating reactance, transformer impedance, no-load and full-load power losses, dummy resistors, and extended voltage regulation curve from 100 percent load to short circuit on the dc bus.
  - 2) Indoor and outdoor lighting calculations (associated with AC and DC equipment houses).
  - 3) 480 VAC and 125/24 VDC system design calculations, including cables and all equipment sizing, including circuit breakers, fuses, transformers, dc/dc converters, battery chargers and batteries.
  - 4) Structural design calculations (for AC and DC equipment houses, equipment within AC and DC equipment houses, rectifier transformers, AC busway structural supports). Structural calculations shall be in accordance with CBC and other seismic criteria. Calculations shall be signed and stamped by a Professional Civil or Structural Engineer currently registered in the State of California.
  - 5) Seismic calculations (including bracing and support of equipment and devices). Seismic calculations shall be in accordance with CBC and other seismic criteria. Calculations shall be signed and stamped by a Professional Civil or Structural Engineer currently registered in the State of California.
  - 6) Noise level calculations and related abatement measures.
  - 7) Design calculations for miscellaneous systems and devices.

#### 5. Studies

- a. Studies shall be performed and provided for each new traction power facility, pre-engineered AC equipment house, pre-engineered DC equipment house and/or rectifier transformer provided under the Contract.
- b. General
  - 1) The studies shall include single-line and impedance diagrams of the portions of the Auxiliary Power Distribution System that are electrically connected to the traction power facilities. These diagrams shall identify all components considered in the studies and the ratings of all power

devices, including transformers, circuit breakers, relays, fuses, busses, and cables; including initial recommended settings and final settings per manufacturer's recommendations. The resistances and reactances of all cables shall be identified in the impedance diagram. The studies shall contain all written data from the Electric Utility Service Provider regarding maximum available short circuit current, voltage, and X/R ratio of the Electric Utility Service Provider's power system. Similar information shall be requested from the District for the 34.5 kV sub transmission system.

- 2) The studies shall include all protective devices and feeders included under this Contract. The studies shall include all Auxiliary Power Distribution System existing upstream protective devices and feeders supplying the new loads under the Contract. The Electric Utility Service Provider's overcurrent protective device and ground fault protective device for the Electric Utility Service Provider's circuit breaker delivering power to each of the facilities shall be used as a fixed reference and starting point for these studies. Similar information shall be requested from the District for the 34.5 kV sub transmission system.
- 3) The studies shall cover three-phase faults and the line to ground faults to coordinate over-current settings and ground fault settings for proper coordination and protection.
- 4) Electrical load calculations (for sizing feeder and branch circuit breakers, disconnect switches and conductors).
- 5) Voltage drop calculations.
- 6) Site lighting analysis and calculations.
- 7) Ground grid design calculations.
- 8) Calculations associated with electromagnetic compatibility.
- 9) Equipment sizing/rating calculations.
- 10) Low voltage (AC and DC) systems design calculations, including circuit sizing based on voltage drop and current loading, panelboards, and selection of protective devices.
- 11) Calculations for field installed conduit and cable tray fill, and for cable-pulling in conduit.
- 12) Calculations for sizing equipment enclosures and boxes in accordance with NEMA, NEC, CEC, or NESC.
- 13) Contractor shall:
  - a) Obtain from the Electric Utility Service Provider, the District and appropriate vendors the information required to perform all the studies specified in the Contract.
  - b) Contact the Electric Utility Service Provider, the District and obtain the fault data, short circuit contribution, impedance values, and X/R ratio in writing for each traction power facility. A copy of each of the letters shall be submitted to the District and be included in all reports.
  - c) Contact the protective device manufacturers and obtain the ratings and time current curves for all protective devices including fuses,

circuit breakers, motor circuit protectors, relays and overload elements.

- d) Perform all needed field investigation and inspections to properly identify protective devices and their settings and ratings to get the correct information to work with including the correct trip and/or time-current curves.
- e) Perform all needed field investigation and inspections to properly identify equipment and any appropriate settings and nameplate data to get the correct information to work with including impedance values, voltage ratings, base kVA ratings and/or current ratings.
- f) Perform all needed field investigation and inspections to properly identify all cable and wire size, type, size and material for use in the studies.
- g) Determine the cable and wire lengths and protective conduit type (plastic, fiber glass) for use in the studies.
- c. Studies shall include, but not limited to, the following:
  - 1) Short Circuit/Fault-Current Study: The study shall provide interrupting ratings of equipment overcurrent protection devices and conductors for all non traction power equipment, components, wires, and cables located at traction power facilities.
  - 2) Protective Device Coordination Study: The study shall include coordination on protective relay characteristics and settings, ratios and characteristics of associated current transformers, power fuses, circuit breaker trip characteristics and settings, and AC surge arresters and grounding requirements.
  - 3) Arc Flash Study: This study shall calculate, determine, and report the "arc flash protection boundary", incident energy, voltage shock hazard, limited/restricted and prohibited approach boundaries, "personal protective equipment" level, and safety label design (including specific information to be communicated on the labels) that should be posted on non traction power equipment. This study shall be performed in conjunction with the short circuit calculations and protective device coordination, and the results shall be tabulated with all identified equipment or short circuit interrupting items in the short circuit and protective device coordination studies.

E. Traction Power Cables and LV (Non-Traction Power) Equipment Vendor Deliverables

1. Product Data

- a. Product data shall be provided for all equipment, cables, materials and appurtenances provided under the Contract.

F. Professional Architectural/Engineering Design Deliverables

1. Construction Drawings

- a. Construction drawings shall be provided for all traction power facilities, inter and intra building raceway/ductbank systems and/or traction power system equipment located in ancillary spaces (e.g. train control rooms/houses) provided under the Contract.
- b. Construction drawings shall include, but not limited to, the following:
  - 1) Table of Contents
  - 2) Symbols, abbreviations, device tables, equipment designations, and notes used on all design drawings.
  - 3) Track plans, sections and details.
  - 4) Civil site plan, sections, elevations, details and geometry data.
  - 5) Grading, drainage and paving plans, sections, elevations and details
  - 6) Composite plans, sections and details of utility rearrangements.
  - 7) Equipment foundation plans, sections, elevations and details.
  - 8) Perimeter security barrier and gate plan, sections, elevations and details.
  - 9) Mechanical site plans, sections and details.
  - 10) Grounding grid, bonding systems design, including ground test stations, ground bus, and grounding conductor layouts and equipment enclosure grounding details.
  - 11) Inter and Intra building underground ductbank plans, elevations, sections and details.
  - 12) AC and DC cable trench plans, elevations, sections and details.
  - 13) Exposed conduit arrangements plans within the traction power facilities and/or ancillary spaces.
  - 14) Equipment and field device layouts drawn to scale and showing physical dimensions and layouts shall consist of:
    - a) Plan views, including floor plans of complete equipment assemblies showing also clearances necessary for installing equipment, equipment base details, available space for entrance of power and control cables, and preliminary dimensions of major sections.
    - b) Elevation views, showing locations of control and protective devices on panels.
    - c) Section views of each non-identical unit, showing bus and equipment locations, accessibility for maintenance and power and control cable entrances.
  - 15) Drawings depicting the traction power facility, adjacent tracks and interconnecting underground ductbanks, and other related interfacing equipment and facilities.
  - 16) Single-line metering and relay diagrams.
  - 17) Cable block diagrams
  - 18) Cable routing plans.

- 19) Power and lighting plans.
  - 20) Low voltage (480 V AC, 240 V AC and 120 V AC) detailed systems design, including panelboards, protective devices, loads, and conductor sizing.
  - 21) Mounting details for field installed equipment, conduit, cable tray and mounting hardware.
  - 22) Auxiliary equipment (e.g. transformer) schematic diagrams.
  - 23) Detailed development of schedules (conduit/cable tray, underground structures, panelboards and cables) in accordance with the templates provided in the Contract.
  - 24) Underground structure development plans depicting conduit sizes and allocation on all surfaces.
  - 25) Complete equipment and device nameplate data, and warning signs; including legends, letter sizes, material, and color information.
  - 26) Contact rail schematic.
  - 27) Contact rail layout plans.
  - 28) Contact rail localized layout plans (e.g. special trackwork, MOWs, pedestrian crossings, etc.).
  - 29) Contact rail system installation and component details.
  - 30) Trackside manual disconnect switch installation plan, d=sections, elevations and details.
  - 31) Incidental/miscellaneous details.
2. Technical Construction Specifications
    - a. Where the contract technical requirements are not signed and sealed by a licensed Professional Engineer for the scope of work detailed in the Contract, the Contractor shall provide 100 percent technical construction specifications (that represents the Contractor's design) signed and sealed by their Professional Architectural/Engineering sub-contractor.

**G. Closeout Procedures**

1. Refer to Section 01 77 00, Closeout Procedures and Section 01 78 39, Contract Record Documents for additional requirements.
2. Provide hard and electronic copies in accordance with Section 01 33 00, Submittal Procedures of the approved product and design deliverables, updated to account for final as-built and tested conditions, specified herein and elsewhere in the Contract.

**1.18 ASSET MANAGEMENT**

- A. Provide the following information for every system, piece of equipment, assemblies, sub-assemblies, components and software provided under the Contract:

1. Manufacturer's Name, Address, Email Address, and Contact Telephone Number.
  2. Description and Model Number.
  3. Unique Identifier (e.g. Part #, Serial #) inclusive of design revision.
  4. Location where the entity is installed (e.g. MPR xxx is installed at TPF xxx, Circuit Breaker 172-xx)
  5. Dates of manufacture, on-site installation and put into revenue service.
  6. Cross references to documentation (e.g. design, O&M manuals, test records, maintenance procedures and required frequencies, equipment settings as delivered, etc.)
- B. The information shall be formatted in accordance with the District's asset management register requirements prior to submission to the District. Reference Attachment A for the format.

#### **1.19 ADMINISTRATIVE REQUIREMENTS**

- A. Refer to the following Sections for additional requirements:
1. Section 01 31 19 Project Meetings.
  2. Section 01 32 16 Construction Progress Schedules.
  3. Section 01 35 14 Operating System Interface.
  4. Section 01 35 24 Construction Safety.
  5. Section 01 35 33 Security Procedures.
  6. Section 34 21 70 Traction Power Facilities Installation Requirements
- B. As the Work, detailed in Section 01 11 00, Summary of Work and elsewhere in the Contract, is on and/or adjacent to operational trainway, operational facilities, Public ROW and/or facilities operated by third parties, the construction and testing activities shall be managed to minimize the impact and risks to revenue services, public and third party personnel within the working hours noted elsewhere in the Contract.
- C. Sequence and schedule all construction and testing activities to ensure adequate time allowances for
1. Work plan, track allocation, and other approvals.
  2. Pre-planned/known special events undertaken by the District and/or third parties.
  3. Scheduled routine maintenance by District personnel.

4. Scheduled work activities by other contractors working on the District.
- D. Conduct pre-activity meetings at least seven calendar days prior to scheduled activities with all applicable stakeholders. Notify all stakeholders of cancelled construction and/or testing activities no later than two calendar days prior to planned start date.

## **1.20 DELIVERY, STORAGE AND HANDLING**

- A. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements for requirements.

## **1.21 JOBSITE CONSIDERATIONS**

- A. Examination
1. Examine areas and conditions.
  2. Note items that may infringe on the necessary clearances and other non-compliances. Promptly bring noted issues to the attention of the Engineer for direction and approval before proceeding.
- B. Protection
1. Protect and secure the Jobsite until final acceptance of the Work by the District. Damage to and/or lost equipment, materials and/or cables shall be replaced, re-installed and retested (as applicable) by the Contractor at no additional costs to the District.
  2. Protect in-place existing installations delineated on the Contract Drawings. Damage to existing installations shall be repaired by the Contractor at no additional costs to the District.
  3. Refer to Section 34 21 70, Traction Power Facilities Installation Requirements for additional requirements.
- C. Maintenance
1. Maintain equipment furnished under this Contract in accordance with the manufacturer's recommendations and statutory requirements until final acceptance of the Work by the District.
- D. Cleaning
1. Refer to Section 01 74 14, Cleaning, for additional requirements.
  2. Remove all waste materials from the Jobsite(s) at no additional cost to the District.



## **1.22 WARRANTY**

- A. Refer to the General Condition and Supplementary Conditions for additional requirements.
- B. Contractor shall ensure that apart from batteries, a warranty for the complete Traction Power System is provided and signed by the equipment manufacturer and the Contractor agreeing to correct system deficiencies and replace components that fail in materials or workmanship.
- C. Provide extended warranties for equipment as prescribed herein:
  - 1. Warrant AC and DC equipment houses to be free from defective materials and workmanship, water leakage and seepage, and condensation for a five-year period commencing at the completion of the standard two year warranty.
  - 2. Warrant rectifier transformers to be free from defective materials and workmanship, for a five-year period commencing at the completion of the standard two- year warranty
  - 3. Warrant batteries to be free from defective materials and workmanship for one year from the date the battery is placed into revenue service and 19 years, pro rata, to deliver not less than 80 percent of its rated capacity.

## **1.23 CLOSEOUT SUBMITTALS**

- A. Refer to Section 01 77 00, Closeout Procedures, and Section 01 78 39, Contract Record Documents, for additional requirements.
- B. Provide hard and soft copies of the following documentation:
  - 1. Permits.
  - 2. Operations and Maintenance Manuals.
  - 3. Training Manuals.
  - 4. Record Documentation.
  - 5. Equipment Vendor Design and Product Deliverables.
  - 6. Guarantee and Warranty Documentation.
- C. Software
  - 1. Provide a listing of “as-built” passwords for all software products furnished under the Contract.
  - 2. Provide six electronic copies of all software associated with the operation of each traction power facility and their associated equipment, including but not limited to the following equipment provided under this contract:

- a. RTAC and HMI at the C02 Cabinet.
- b. Emergency transfer trip system.
- c. Sectionalization breaker blocking scheme.
- d. Negative ground device.
- e. MPRs and IPRs.
- f. 125 V DC battery monitoring system.
- g. Communication switches, routers and/or signal processing equipment.
- h. Fire detection system.
- i. Access control system.
- j. HVAC controller.

#### **1.24 MAINTENANCE MATERIAL**

- A. Provide a complete list of all spare parts (including testing spare parts if purchased by the District) and tools to be delivered to the District.
- B. Provide secure storage facilities for the spare parts and tools (for up to six months).
- C. Coordinate delivery of the spare parts and tools with the Engineer.
- D. Provide keys that were furnished with the equipment and materials to the Engineer.

### **PART 2 – PRODUCTS**

Not Used

### **PART 3 – EXECUTION**

#### **3.25 TRAINING**

- A. Guidelines
  - 1. The Contractor shall provide a training program to enable District personnel to operate, service, test, and maintain the hardware, software, and firmware such that the equipment and systems will perform in accordance with the Contract requirements. The training will be attended by District Maintenance, Engineering, and Training personnel.
  - 2. Training shall not commence until the Engineer has approved the Student Training Materials indicated in this Contract Specifications Section and the Pre-Final Submittal of the Operations and Maintenance Manuals.

3. Training shall be provided by or certified by the primary manufacturers of the contract equipment and software.
4. The initial 240 hours of training shall be completed prior to Acceptance of any equipment.
5. Training shall be provided in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.
6. The training program shall include formal and informal hands on instruction during installation, as appropriate. Provide models, mock-ups, laboratory equipment setups, documentation and aids to carry out the program.
7. Training shall include equipment maintenance and troubleshooting, and using laptop computers for review and checkups for the settings of protective relays, downloading relay event logs and saved event data, and access to programmable logic controller (PLC) data and configuration.
8. Assume that the personnel to be trained have basic electrical skills and experience pertinent to their craft as outlined in District's job descriptions for the involved personnel.
9. The District will furnish space for classroom lectures and equipment training.

B. Instructors

1. The principal instructors provided by the Contractor shall have previous formal classroom instruction training and relevant experience with the provided systems equipment in an operating environment. Submit instructor qualifications and experience 90 days prior to training.

C. Training Materials and Equipment

1. The Contractor shall prepare training course materials, including basic and advanced training program plans, instructor guides, student training materials, and equipment used in classroom demonstrations and hands-on training as described below and submit them to the District for review and approval 90 days prior to the start of the classroom instruction.
2. Provide demonstration PLC and relay equipment for classroom familiarization with the equipment. The equipment shall be powered and operational, allowing students to gain familiarization with equipment operation before operating the equipment in the field. For basic training classes provide one demonstration model of each equipment for every six students. For advanced training classes provide one operational piece of equipment for every three students. The Contractor may use spare parts furnished under this Contract as training aids for demonstration and for practical exercises in adjusting, testing, disassembly, and assembly of equipment. Ensure that the spare parts so used are repackaged and returned to the District spare parts storage in their original condition.

D. Training Program

1. The Training Program shall include formal instruction with the Contractor providing any models, mockups, documentation, and aids used to carry out the Training.
2. Assume that District's personnel to be trained have basic knowledge of existing BART traction power system systems and equipment similar to those to be taught in the classroom. However, assume that trainees have no specific knowledge of the features of equipment, protective relay, and PLC features such as controls, protection, metering, and monitoring functions of equipment or systems provided by this Contract. The Contractor may request the job descriptions from the Engineer.
3. BART maintenance staff work on three shifts:
  - a. Day: 7am - 3pm
  - b. Swing: 3pm - 11pm
  - c. Graveyard: 11pm - 7am
4. The District will try to accommodate all instruction during the day shift. However, the Contractor shall accommodate teaching during all three shifts as necessary.

E. Training Program Plan

1. The Contractor shall submit the Training Program Plan in the data package for the Final Design Review as indicated in Exhibit A - Preliminary Submittals List and shall include the following:
  - a. The overall objective(s) of the Training Program.
  - b. A matrix describing each training day including subject(s) to be covered, measurable objectives, type(s) of instruction, time allocation, materials and equipment requirements, and criteria and methods of evaluating achievement of each objective.
  - c. Any special electrical power or other infrastructure requirements for the training site.
  - d. Criteria and methods for evaluating achievement of overall program objectives.
  - e. Training Schedule closely corresponding to the Training Program milestones as indicated in this Contract Specifications Section.
  - f. Training plan shall include written test to evaluate students' grasp of the material presented.

## F. Instructor's Guide

1. The Instructor's Guide shall detail the actions of the instructor during the staged Training Program. There shall be one section for each objective of the Program, and the sections shall be arranged as follows:
2. Section 1. - Title: The title shall be short and descriptive. It shall contain the lesson name and, if applicable, the target population (example: Auxiliary Electric Subsystem Theory of Operation for Traction Power System Technicians).
3. Section 2. - Time To Teach: An estimated time to teach shall be designated for each subject. This is an approximate time frame which shall be variable to accommodate student number and knowledge level.
4. Section 3. - Objective: Each Instructor's Guide shall have one or more performance-based objectives. Each objective shall specify:
  - a. End-of-course behavior expected to be demonstrated by the student.
  - b. Conditions under which the behavior will be demonstrated.
  - c. Measurable minimum level of behavior considered acceptable.
5. Section 4. - References: All sources of materials presented in the Instructor's Guide shall be fully cited. This shall include Operations and Maintenance Manuals, Test Equipment Manuals, other manuals or other documents, including District documents, utilized to develop the training.
6. Section 5. - Equipment and Materials List: List all equipment and materials needed to teach the course material in the Instructor's Guide. This includes size and type of facility; all instructional aids such as overhead transparencies and/or charts and applicable projectors; student handouts such as books, drawings, schematics; and equipment such as tools and parts for disassembly.
7. Section 6. - Introduction: The introduction shall cover at least the following areas:
  - a. Introduction of the subject covered by the lesson.
  - b. Objectives of the lesson.
  - c. Outline of the lesson.
  - d. Schedule of the lesson activities.
8. Section 7.- Presentation
  - a. The presentation shall be in outline form.
  - b. The presentation portion of the Instructor's Guide shall be detailed enough to:
    - 1) Allow another instructor with knowledge of the area to teach the class.

- 2) Ensure that the subject delivery is consistent each time the lesson is given.
- 3) Serve as a written record of the specific information presented.
- 4) Cover all tests, quizzes, and other evaluations conducted in conjunction with the lesson.
- 5) Ensure that all facts and information the trainees receive are written in the guide or referenced.

9. Section 8. - Attachments

- a. The following materials shall be supplied with each Instructor's Guide:
  - 1) Reproducible "A"-size copies of any overhead transparencies used with the lesson.
  - 2) Slides, pictures, charts, video, or magnetic media used in support of the lesson.
  - 3) Complete student handout package.
  - 4) Copy of any referenced material used in the lesson.

G. Student Training Materials

1. One complete set of Student Training Materials shall be provided for each scheduled student as indicated in Exhibit A - Preliminary Submittals List. A copy of any material from the Operation and Maintenance Manual that is referenced by the training class shall be provided with each set of Student Training Materials. The Student Training Manual shall include one unit for each objective of the Program. Each unit shall be arranged in seven sections that correspond and correlate with the first six sections of the Instructor Guides as indicated herein.
2. The first six sections shall match the first six sections of the Instructor Guide as follows.
  - a. Section 1. - Title
  - b. Section 2. - Time To Teach
  - c. Section 3. - Objective
  - d. Section 4. - References
  - e. Section 5. - Equipment and Materials List
  - f. Section 6. - Introduction
3. Section 7 - Presentation shall include all materials covered in the Instructor's Guide for the subject unit.
  - a. The Student Manual shall be detailed enough to serve as a future reference document for the student.

- b. Include narrative descriptions of substation control scheme and circuit breaker interlock functions.
- c. All overhead transparencies and other visuals used in the class shall be reproduced in 8.5 by 11 inches' format in the Student Manuals. Such visuals shall either appear in the sequence presented, or be clearly referenced at that point in the text and located at the end of the text.
- d. Any demonstration equipment utilized in the lesson shall be represented by illustration of the equipment plus illustrations of any applicable details.

H. Staged Training Program

- 1. Training conducted at BART facilities or a location determined by the Engineer. Special power and supporting requirements shall be included in the Training Program Plan as indicated.
- 2. Training shall be divided into three sections: Basic training, advanced training, and refresher training.
- 3. Basic training shall consist of 120 hours of training and shall occur prior to commissioning of the first substation.
  - a. There shall be 72 students total in basic training.
  - b. There shall be approximately 12 students in each class, consisting of maintenance electricians, engineers, and one technical trainer.
  - c. There shall be six classes.
  - d. Each class shall have duration of 20 hours.
- 4. Advanced training shall consist of 120 hours of training and shall occur within 60 days following commissioning of the first substation.
  - a. There shall be 18 students total in advanced training.
  - b. There shall be approximately six students in each class, consisting of maintenance staff, engineers, and one trainer.
  - c. There shall be three classes.
  - d. Each class shall have duration of 40 hours.
- 5. Refresher training shall occur every two years, and shall consist of two basic and one advanced class. Refresher training shall be provided at completion of each subsequent substation.
  - a. There shall be 24 students total in basic refresher training.
  - b. There shall be approximately 12 students in each basic refresher training class, consisting of maintenance electricians, engineers, and one technical trainer.
  - c. There shall be 12 students total in advanced refresher training.

- d. There shall be approximately six students in each advanced class consisting of maintenance staff, engineers, and one trainer.

I. Deliverables

- 1. Deliverables shall include the Training Program Plan, the Instructor's Guides and Attachments, Student Training Materials, Staged Training Program Classes, and Final Deliverables.
- 2. Submit Final Training Deliverables following completion of the first 240 hours of basic and advanced training. The final deliverables shall consist of the following:
  - a. Updated and corrected Instructor's Guides and Attachments.
  - b. Updated and corrected Student Manuals in both hard copy and electronic files in Microsoft Word for Windows.
  - c. Any models, mockups, simulations, classroom relay and PLC equipment, or other materials utilized to stage the Training Program.

**3.26 CONSTRUCTION EQUIPMENT**

- A. The Contractor's on-track construction equipment shall be designed and constructed to operate within the dynamic envelope for District trains as specified in the BART Facilities Standards.

**3.27 CONTRACT INTERFACES**

- A. Electric Utility Service Provider (Pacific Gas and Electric (PG&E))
  - 1. Coordinate all utility requirements with PG&E and ensure that all the design and construction requirements of PG&E are complied with in the manufacture of the applicable electrical equipment and construction of subgrade structures / ductbanks (associated with the incoming power sources) provided under the Contract.
  - 2. PG&E's local distribution network is 21 kV and 12 kV, three-phase, 60 Hz. Additional technical data, such as fault levels, grounding requirements, and so forth, shall be obtained by the Contractor from PG&E, as needed.
  - 3. Conform to PG&E's service requirements and the Contract.
  - 4. In addition to coordinating with the PG&E, the Contractor shall be responsible for the following:
    - a. Obtaining the necessary permits for the Work associated with the new and temporary power services from PG&E and the local authorities having jurisdiction.
    - b. Complete the final design of the underground ductbanks and structures, transformer pads associated with the new incoming power services



between the designated point of connection (to PG&E's distribution network) and the traction power facility(ies).

- c. Submit applications and request new power services at the traction power facilities as indicated in the Contract.
- d. Furnish and install underground ductbanks, structures and equipment pads, between PG&E's distribution network and traction power facility(ies).
- e. Furnish, install, test and commission the 21 kV or 12 kV/480V transformer and all cables between the PG&E's distribution network and the line side of the transformer at the traction power facility(ies).
- f. Furnish, install, test and commission all cables between the load side of the 21 kV or 12 kV/480V transformer and metering enclosure at the traction power facility(ies).
- g. Furnish and install the metering enclosure associated with the metering equipment; and all hardware and support equipment in the metering enclosure.
- h. Furnish, install, terminate and test the revenue metering equipment; associated CTs and PTs; and the low-voltage wirings and termination hardware.
- i. Coordinate the ductbank/utility pole interface with PG&E.
- j. Ensure the Contractor-furnished equipment is mechanically and electrically compatible and complies with all requirements of PG&E.
- k. Schedule inspections with PG&E and local authorities having jurisdiction (where applicable).

B. Third Party Utility Service Providers (for Water, Storm Water and Sewage)

1. Coordinate all utility requirements with the third-party utility service providers and ensure that all the design and construction requirements of the third-party utility service providers are complied with in the manufacture of the applicable components/materials and construction of subgrade structures/utilities (associated with the incoming water supply and, outgoing storm water and sewage connections) provided under the Contract.
2. Technical data shall be obtained by the Contractor from the respective third-party utility service providers, as needed.
3. Conform to third-party utility service provider's service requirements and the Contract.
4. The Contractor shall be responsible for the following:
  - a. Obtaining the necessary permits for the Work associated with the new and temporary power services from the third-party utility service providers and the local authorities having jurisdiction.

- b. Complete the final design of the underground utilities and structures between the designated point of connection and the traction power facility(ies).
- c. Submit applications and request new services at the traction power facilities as indicated in the Contract.
- d. Furnish and install underground utilities and structures between the third-party utility service provider's infrastructure and traction power facility(ies).
- e. Furnish, install, test and commission materials and components between the third-party utility service provider's infrastructures and the traction power facility(ies).
- f. Coordinate the interface requirements with third-party utility service providers.
- g. Ensure the Contractor-furnished materials and components are mechanically compatible and complies with all requirements of the third-party utility service providers.
- h. Schedule inspections with the third-party utility service providers and local authorities having jurisdiction (where applicable).

**END OF SECTION 34 21 01**